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First records of three fishes, and southern records of a further four fishes, from New South Wales, Australia

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Abstract: A study of fishes from Port Stephens in New South Wales, Australia has identified first records for three species in New South Wales — *Genicanthus watanabei* (Yasuda & Tominaga, 1970), *Parupeneus indicus* (Shaw, 1803), and *Plectorhinchus chaetodonoides* (Lacépède, 1801) — and southernmost records for a further four species: *Cantherhines fronticinctus* (Günther, 1866), *Coris bulbifrons* (Randall & Kuiter, 1982), *Mulloidichthys vanicolensis* (Valenciennes, 1831), and *Paracirrhites forsteri* (Schneider, 1801). New sightings were up to 980 km south of previous records, indicating prolonged survival of tropical fish larvae in the East Australian Current.

Key words: Port Stephens; East Australian Current; climate change

Southeastern Australia is an area where marine species will increasingly be impacted by climate change (Poloczanska et al. 2007), with the strengthening of the East Australian Current (EAC), and warming waters, predicted to influence species distributions in this region (Poloczanska et al. 2007; Figueira and Booth 2010). Larval transport along the east coast of Australian is strongly influenced by the EAC (Booth et al. 2007), and strengthening of this current is likely to result in increased frequency of occurrence, and prolonged survival post-settlement, of tropical larvae at southern locations. To date, range extensions for marine species have been identified in eastern Australia for fishes (Figueira and Booth 2010), corals (Baird et al. 2012), and urchins (Ling et al. 2009b), and recent southernmost records have been reported for sea slugs (Nimbs et al. 2016), and sea anemones and their commensal shrimps (Scott et al. 2015).

This southward transportation and settlement of marine larvae can negatively impact ecosystems, as demonstrated by the spread of the urchin *Centrostephanus rodgersii* (Agassiz, 1863) to Tasmania, causing the extensive loss of kelp forests (Ling et al. 2009a). It is therefore important to monitor distributional changes for species, to provide early detection of potential range extensions, and allow development of management strategies to identify and address their possible ecological impacts (Sexton et al. 2009).

Here we examine records of fishes from Port Stephens (32.717° S, 152.105° E) in New South Wales (NSW), Australia (Figure 1) to identify new southern records. Port Stephens lies within the Port Stephens-Great Lakes Marine Park (PSGLMP), the largest marine park in NSW (NSWMPA 2010), and shelters a wide range of mainly temperate fish species, with tropical fish larvae transported to the area over summer by the EAC (Davis et al. 2016).

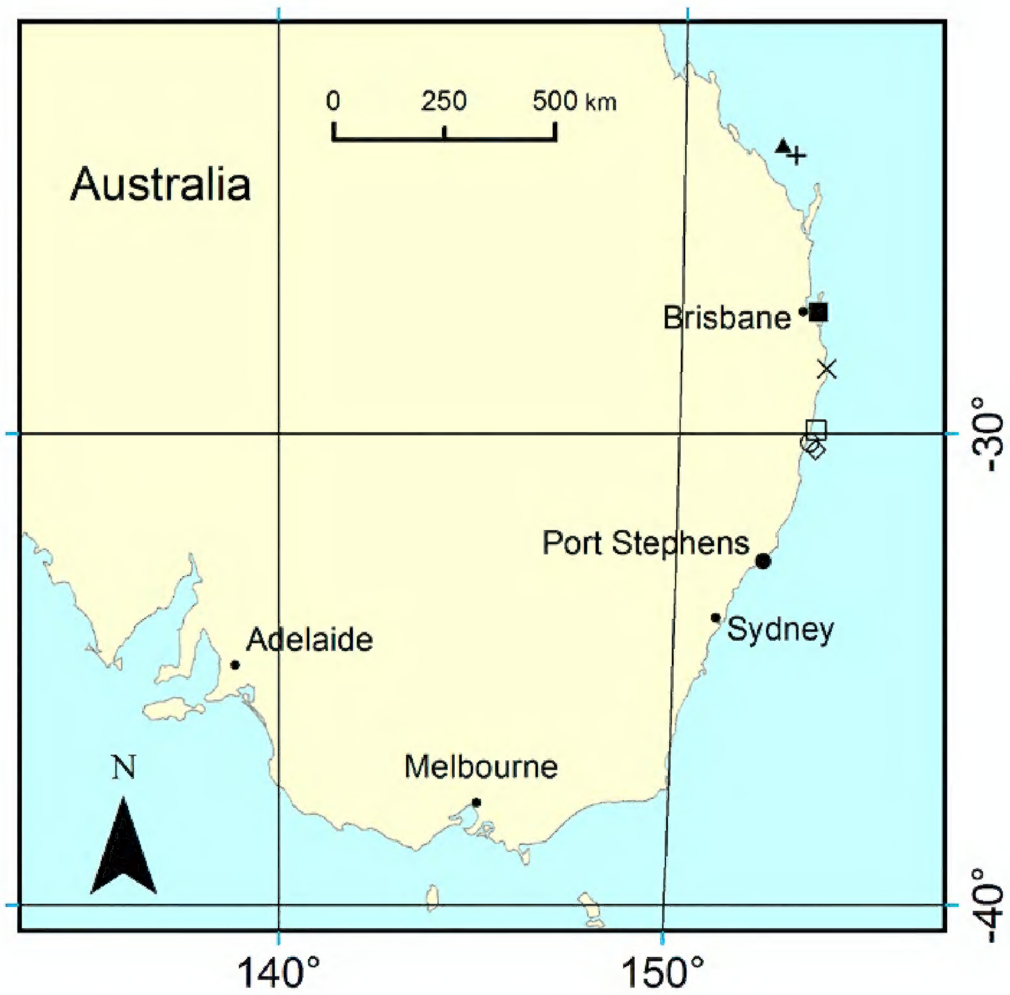

Figure 1. Map of Australia with locations of major cities and new species records in Port Stephens shown by (●) and locations of previous southern records shown by; *Genicanthus watanabei* (▲), *Plectorhinchus chaetodonoides* (+), *Parupeneus indicus* (■), *Coris bulbifrons* (×), *Paracirrhites forsteri* (□), *Mulloidichthys vanicolensis* (○), and *Cantherhines fronticinctus* (◇). Datum WGS84.

Data on occurrences of more than 400 fishes were collected (pers. obs.), from surveys conducted in the Port Stephens region, approximately every two weeks, from 2009 to 2016. The surveys involved more than 800 dive/hours by the author and dive buddy (ND), with both divers trained in quantitative assessment of fish assemblages. Data was assembled from three datasets: 1) 216 underwater visual census (UVC) transects recording fish abundance along 25 m × 5 m transect tapes, to a height of 5 m as tapes were laid, with cryptic species recorded over the same area during subsequent thorough searches of the substrate (Davis et al. 2016); 2) 325 UVC transects recording fish abundances and sizes along two parallel 50 m × 5 m strips either side of a transect tape, with subsequent searches for cryptic species along two 50 m × 1 m strips either side of the tape, as per Reef Life Survey methods (Edgar and Stuart-Smith 2014); 3) roving fish observations from more than 300 dive/hours by the author and dive buddy (ND). Species were identified *in situ*, with digital photographs taken for later species identification where required. No samples were collected as the majority of dives were conducted within no-take zones in the PSGLMP.

Species were identified from photographic records, using reference literature for fishes of Australia (Hutchins and Swainston 1986; Kuiter 1993; Kuiter 1996; Allen et al. 2003; Stuart-Smith et al. 2015). Southernmost occurrences for species were determined from the reference literature, and by checking distributional data from: the Global Biodiversity Information Facility (GBIF 2016); the Ocean Biogeographic Information System (OBIS 2016); the Atlas of Living Australia (ALA 2016); the Australian Faunal Directory (ABRS 2009); Reef Life Survey – survey data (RLS 2016); and Australian Museum records for fishes of Sydney harbour (AM 2016). The review of species distributions identified three species that were first records in NSW, and a further four species that were southernmost records in NSW by at least 250 km (Table 1).

Three species identified, *Genicanthus watanabei* (Yasuda & Tominaga, 1970) (Pomacanthidae), *Plectorhinchus chaetodonoides* (Lacépède, 1801) (Haemulidae), and *Parupeneus indicus* (Shaw, 1803) (Mullidae), have not previously been recorded in the state of NSW. A 2 cm juvenile *G. watanabei* was sighted at Little Beach in Port Stephens on 15 November 2015, sheltering in rubble at a depth of 3 m (Figure 2). *Genicanthus watanabei* displays sexual dimorphism, with females and juveniles, as reported here, being light bluish-grey in colour with a black blue-edged line over the eye, and black fin margins (Figure 2); while males having a series of longitudinal black lines along the lower body and anal fin (Kuiter 1996; Allen et al. 2003). A 4 cm juvenile *P. chaetodonoides* was sighted at Fly Point on 23 March 2015, under a rock ledge at a depth of 6 m (Figure 3). *Plectorhinchus chaetodonoides* displays dramatic changes between juveniles and adults, with juveniles, as reported here, having brown bodies with large white blotches (Figure 3), while adults have white bodies with black spots (Kuiter 1996; Allen et al. 2003). On 12 May 2013 a 12 cm *P. indicus*

Table 1. Family and species for southernmost records for fishes in New South Wales (NSW), Australia with; locations, dates and abundances for sightings; previous southern record locations; and distance between locations

Family	Species	Locations of southern records in Port Stephens, NSW with date : abundance	Location and Australian state for previous record	Distance between locations
Pomacanthidae	*Genicanthus watanabei* (Yasuda & Tominaga, 1970)	Little Beach (32.714° S, 152.150° E) 15 Nov. 2015 : 1	Lady Musgrave Island, Queensland (23.900° S, 152.383° E)	980 km
Haemulidae	*Plectorhinchus chaetodonoides* (Lacépède, 1801)	Fly Point (32.714° S, 152.152° E) 23 Mar. 2015 : 1	Lady Elliott Island, Queensland (24.113° S, 152.711° E)	958 km
Mullidae	*Parupeneus indicus* (Shaw, 1803)	Halifax Point (32.710° S, 152.159° E) 12 May 2013 : 1	Moreton Bay, Queensland (27.417° S, 153.350° E)	600 km
Monacanthidae	*Cantherhines fronticinctus* (Günther, 1866)	Fly Point (32.714° S, 152.152° E) 07 May 2015 : 1 28 Mar. 2016 : 1 Pipeline (32.718° S, 152.141° E) 10 Apr. 2010 : 1 26 Apr. 2010 : 1	Coffs Harbour, NSW (30.350° S, 153.408° E)	289 km
Labridae	*Coris bulbifrons* (Randall & Kuiter, 1982)	Cabbage Tree Island (32.689° S, 152.227° E) 01 Aug. 2011 : 1 25 Aug. 2012 : 1	Byron Bay, NSW (28.633° S, 153.616° E)	470 km
Mullidae	*Mulloidichthys vanicolensis* (Valenciennes, 1831)	Fingal Island (32.741° S, 152.195° E) 02 Apr. 2016 : 1	Solitary Islands, NSW (30.202° S, 153.266° E)	300 km
Cirrhitidae	*Paracirrhites forsteri* (Schneider, 1801)	Pipeline (32.718° S, 152.141° E) 07 Apr. 2016 : 1	Solitary Islands, NSW (29.930° S, 153.390° E)	332 km

Figures 2–9. Fish species with new southern records in Port Stephens, New South Wales, Australia with date of sighting. **2:** *Genicanthus watanabei,* 15 November 2015. **3:** *Plectorhinchus chaetodonoides*, 23 March 2015. **4:** *Parupeneus indicus,* 12 May 2013. **5:** *Cantherhines fronticinctus*, 28 March 2016. **6:** *Coris bulbifrons,* 1 August 2011. **7:** *Coris bulbifrons,* 25 August 2012. **8:** *Mulloidichthys vanicolensis*, 2 April 2016. **9:** *Paracirrhites forsteri*, 7 April 2016.

was observed schooling with *Parupeneus signatus* (Günther, 1867) (Mullidae) at Halifax Point at a depth of 10 m (Figure 4). *Parupeneus indicus* is distinguished by a bright yellow patch on the body, and a black spot on the tail base (Kuiter 1996; Allen et al. 2003).

The four species that were southernmost records in NSW were *Cantherhines fronticinctus* (Günther, 1866) (Monacanthidae), *Coris bulbifrons* (Randall & Kuiter, 1982) (Labridae), *Mulloidichthys vanicolensis* (Valenciennes, 1831) (Mullidae), and *Paracirrhites forsteri* (Schneider, 1801) (Cirrhitidae). Single adult (15–20 cm) *C. fronticinctus* have been observed on four occasions in Port Stephens, twice at the Pipeline site (10 April 2010, 26 April 2010), and twice at Fly Point (7 May 2015, 28 March 2016; Figure 5). *Cantherhines fronticinctus* is distinguished by a dark blotch between the eyes and a lighter patch at the tail base (Allen et al. 2003; Stuart-Smith et al. 2015). Two individuals of *C. bulbifrons* were observed at Cabbage Tree Island, a 7 cm juvenile on 1 August 2011 (Figure 6) and a 20 cm subadult on 25 August 2012 (Figure 7). *Coris bulbifrons* exhibits substantial changes in colouration as it grows, with juveniles distinguished by a distinct black and white colour pattern (Kuiter 1993, Figure 6), transforming to a scribbled pattern as subadults (Figure 7), and then to a blue colour as adults (Stuart-Smith et al. 2015). On 2 April 2016 a 15 cm *M. vanicolensis* was sighted at Fingal Island (Figure 8), with this species distinguished by yellow fins and a yellow stripe from the eye to the tail (Kuiter 1996; Allen et al. 2003). On 7 April 2016 a 5 cm juvenile *P. forsteri* was observed at the Pipeline (Figure 9) with this species distinguished by freckle-like red spots on the head, with variable body colouration (Kuiter 1996; Allen et al. 2003).

All species reported here are known in Australian waters, but were found more than 250 km south of their previous southernmost records on the Australian mainland, with three species not previously reported in the state of NSW. Sightings were all of individual, mostly juvenile, fishes, with individuals often present at sites for only a few days (pers. obs.). The species found furthest from previously recorded locations was *G. watanabei* with the sighting reported here 980 km south of the previous southern record at Lady Musgrave Island in Queensland (ALA 2016). *Genicanthus watanabei* is widespread in the Pacific (Allen et al. 2003), while in Australia it is generally found in northern Queensland on deep reef walls (Kuiter 1996). *Plectorhinchus chaetodonoides* was also found well south of previous records, with the sighting reported here 958 km south of the previous record from Lady Elliott Island in Queensland (ALA 2016). *Plectorhinchus chaetodonoides* juveniles are reported to be solitary (Allen et al. 2003), and to occur in coastal and lagoon habitats throughout central and northern Queensland (Kuiter 1996). The sighting of *P. indicus* at Halifax Point also represents a first record in NSW, with the previous southern record from Moreton Bay in Queensland, 600 km to the north (ABRS 2009). *Parupeneus indicus* grows to 30–40 cm and occurs on coastal and inner reefs in central and northern Queensland (Kuiter 1996) and in the Indo-West Pacific (Allen et al. 2003). The recording of three new species in NSW, as reported here, indicates that either the EAC has transported larvae for these species very large distances south (600–980 km); or that breeding populations for these species exist south of their previously recorded ranges. Studies examining larval transport in the EAC have indicated that fish species can be carried for hundreds of kilometers (Booth et al. 2007; Pearce et al. 2011). Planktonic larvae can survive for periods of 20–45 days (Booth et al. 2007) and, with the EAC flowing at average speeds of ~0.5 m/s (Ridgway and Dunn 2003), larvae can potentially travel up to 2,000 km, with the southernmost records reported here well within this range.

Coris bulbifrons was sighted on two occasions in Port Stephens, with both sightings at the same dive site, one year apart. *Coris bulbifrons* is listed as "Vulnerable" on the IUCN Red List due to its restricted range and susceptibility to fishing pressure (IUCN 2015), with the distribution of *C. bulbifrons* localised to Tasman Sea islands (Stuart-Smith et al. 2015). Sightings of this species have, however, been reported previously from the NSW coast (Kuiter 1993), with the records reported here representing a 470 km increase in the southernmost record for the species, with the previous available record at Byron Bay in northern NSW (ALA 2016). The establishment of a population of this species along the coast of eastern Australia would constitute a significant range extension, given the vulnerable status of this species, and continued monitoring of occurrences of this species along the coast of eastern Australia is therefore warranted.

Sightings of single adult (15–20 cm) *C. fronticinctus* were made on four occasions over a six-year period (2010 to 2016). Previously *C. fronticinctus* has been reported on outer reefs, with an Indo-Pacific distribution (Allen et al. 2003), and in Australia the species has primarily been found off the coast of Queensland and Northern NSW (Stuart-Smith et al. 2015). The previous southern record for *C. fronticinctus*, at Coffs Harbour (ALA 2016), was relatively close (289 km north) to the records reported here, with survival of some individuals to adulthood in Port Stephens indicative that this species can tolerate environmental conditions in the Port Stephens estuary for prolonged periods. The recorded sightings for *M. vanicolensis* and *P. forsteri* were also relatively close to previous southern records, for both species, at the Solitary Islands in central NSW 300–332 km to the north (ALA 2016). Both *M. vanicolensis* and *P. forsteri* occur throughout the Indo-pacific, with *M. vanicolensis* usually occurring in schools on coastal reefs and lagoons,

and *P. forsteri* generally found as individuals or in pairs on coral outcrops (Allen et al. 2003).

Due to the transient appearances of most of the species recorded, it cannot be concluded that the sightings reported here constitute range extensions, with range extensions indicated by species persistence in an area (Sexton et al. 2009). Range extensions can be restricted by food and habitat limitations at settlement (Feary et al. 2014) and the new southern records reported here provide information about species that have the potential to settle and survive in new locations and may therefore, at some point in the future, expand their ranges to invade established ecosystems. Where invading species are able to colonise new areas they have the potential to compete for resources with established species, leading to negative impacts on existing ecosystems (Ling et al. 2009a). The majority of the southern records detailed here, however, were single occurrences of juvenile fish, with these individuals generally disappearing from sites within a few days (pers. obs.) and impacts on ecosystems by these short-term immigrants were therefore likely to be small. Results do show prolonged survival of pelagic tropical fish larvae, with records shown here to be up to 980 km south of previously reported locations. Predicted strengthening and warming of the EAC is likely to contribute to an increase in survival, and transport distances, for larvae of tropical fishes (Poloczanska et al. 2007), and this may promote range extensions, and increased frequency of occurrence. Ongoing monitoring is required to detect these distributional changes, and further study is needed to determine how increased settlement of tropical fish species in southern locations will impact temperate ecosystems and fish assemblages.

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